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LANES I Users' Guide

Joe Jordan

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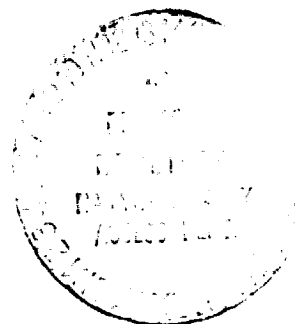
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LANES I Users' Guide

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## **Symbols and Abbreviations**

<b>A</b>	<b>Analyze</b>
<b>AL</b>	<b>Arm Length</b>
<b>AT</b>	<b>Absorption Time</b>
<b>B</b>	<b>Bye (exit program)</b>
<b>D</b>	<b>Delay Statistics</b>
<b>E</b>	<b>Edit</b>
<b>E</b>	<b>Event time trace</b>
<b>E</b>	<b>Exit (the current function)</b>
<b>FODS</b>	<b>Fiber Optic Demonstration System</b>
<b>G</b>	<b>Go (execute the function)</b>
<b>GT</b>	<b>Gap Time</b>
<b>HS</b>	<b>Header Size</b>
<b>IP</b>	<b>Iteration Parameter</b>
<b>IS</b>	<b>Iteration Step Size</b>
<b>ISO</b>	<b>International Standards Organization</b>
<b>IT</b>	<b>Inter-arrival Time</b>
<b>LANES</b>	<b>Local Area Network Extensible Simulator</b>
<b>LC</b>	<b>List Control parameters</b>
<b>LM</b>	<b>List Model parameters</b>
<b>M</b>	<b>Message history</b>
<b>MQ</b>	<b>Maximum Queue length</b>
<b>MS</b>	<b>Message Size</b>
<b>NACK</b>	<b>Negative ACKnowledgment</b>
<b>NI</b>	<b>Number of Iterations</b>
<b>NN</b>	<b>Number of Nodes</b>

## **Symbols and Abbreviations (Continued)**

<b>NR</b>	<b>Node Range</b>
<b>OSI</b>	<b>Open Systems Interconnection</b>
<b>OV</b>	<b>Output Volume</b>
<b>Q</b>	<b>Queue statistics</b>
<b>QD</b>	<b>Queue-loading Delay</b>
<b>R</b>	<b>Read</b>
<b>RN</b>	<b>Random-delay maximum on Non-negative numbers</b>
<b>RS</b>	<b>Random-delay Stepsize</b>
<b>RT</b>	<b>Run Time</b>
<b>S</b>	<b>Simulate</b>
<b>S</b>	<b>Summary statistics</b>
<b>SC</b>	<b>Statistics Collection</b>
<b>SP</b>	<b>Speed of Propagation</b>
<b>SW</b>	<b>Slot Width</b>
<b>TR</b>	<b>Transmission Rate</b>
<b>TT</b>	<b>Transmit-again Time</b>
<b>W</b>	<b>Write</b>

## LANES I USERS' GUIDE

### Section 0. Introduction

LANES I is the first version of a Local Area Network Extensible Simulator developed at the NASA Ames Research Center. It models the performance of the Fiber Optic Demonstration System (FODS) under a variety of specifiable loading conditions and network characteristics which are described in this document from the user's point of view. The following related documents may also be of interest:

LANES I Functional Specification

LANES I Requirements Specifications  
Human Interface  
Simulation System  
Data Analysis

LANES I Programmer's Maintenance Manual

Section 1 of this User's Guide discusses the basics of how LANES is used to provide a general capability for simulation of FODS. Section 2 summarizes the FODS concept as modelled by LANES. Section 3 describes the computer resources required for running LANES properly. Section 4 is a detailed tutorial on the interactive use of LANES.

## Section 1. Overview of LANES

The Fiber Optic Demonstration System (FODS) computer network concept can be studied with the aid of simulations done with the LANES program. For this purpose, a hypothetical FODS network is characterized with input "model parameters" (e.g., number of nodes); the simulation itself is governed by input "control parameters" (e.g., run-time). LANES requires an input file listing all these parameter values, read in at the beginning of the interactive session. The values can then be edited, reviewed, and even copied out to the same or another file, from within LANES; or, a complete set of new values from another input file can be read in. (See Sections 2, 3, and 4 for input file details.)

When a simulation is executed, the results and the parameter values used are stored, along with an identifying label chosen beforehand by the user, in a database. The results of any simulation archived in that database can be retrieved and displayed for analysis, using LANES. (See Section 3 for further information on the database.)

This summarizes the operations that can be performed in LANES. The main commands available to the user are: Edit, Simulate, Analyze, and Bye (exit option). For each of these top-level commands (except Bye), options exercised within its scope carry out the actual work. (Section 4 discusses the complete set of commands and options.)



## Section 2. The LANES Model of FODS

LANES I models FODS on three levels, roughly corresponding to the ISO-OSI (International Standards Organization - Open Systems Interconnection) paradigm of communication layers. There is a physical layer representing the hardware characteristics and the layout of the network; a data link layer representing the access protocol; and a "load" layer (instead of the five highest layers in the standard scheme) representing the messages in the system. The following discussion explains the way FODS is represented by LANES in terms of the input model parameters.

### 2.1 Load layer

In the simulated communications load on the network, all messages have the same header size (HS). The amount of data in each (excluding the header) is the message size (MS), which depends on the source node. Each message generated at a given source node has a uniformly randomly assigned destination node (other than itself).

Messages are generated according to some probability distribution for "inter-arrival time" (IT), characterized by user inputs. On the other end, a node which has just received and accepted a message is full, and does not become ready to accept another until the end of some "absorption time" (AT), also determined for each node from a user input probability distribution. If the beginning of a new message intended for a node reaches that node during an absorption time, when the node is still dealing with the most recent message sent to it, the entire new message is wasted; the node will return a NACK (negative acknowledgment) when the message ends. When the source node gets the NACK, it schedules a retry to begin as soon after the "transmit-again time" (TT) as the access protocol will permit transmission.

There is a non-negligible "queue loading delay" (QD) which every message takes to become ready for transmission after it has reached the head of the queue at its source node. This applies both between successive transmissions by the same node, and upon loading into a previously empty queue.

The model parameters needed to characterize this layer are as follows:

HS -- header size, (in bits).

MS -- message size, (in bits). In both the input file and any interactive editing, this number must be followed by the lower and upper limits (in that order) for a continuous range of nodes to which it is to be assigned. For example, the number 16384 followed by a

2 and then a 5 would mean that nodes 2 through 5 are all to make messages with size 16384 bits. Several such sets of numbers may be required to cover all the nodes in the network to be modelled.

IT -- inter-arrival time, (in microseconds). This is the mean time between the loading of successive messages at a source node. This number must be followed by lower and upper node range limits and then by a distribution type; thus there are four numbers required for this parameter, (for each different value of IT in the network).

The distribution type is always the last, and its value must be either 1 or 2. If it is 1, then the first in that set of four numbers is to be interpreted as the mean of an exponential distribution. If it is 2, then the first number represents a constant inter-arrival time.

For example, a 2000. followed by 1, 3, and 2, respectively, would mean that nodes 1 through 3 all have a constant inter-arrival time, fixed at 2000 microseconds. A 5000. followed by 4, 4, and 1 would give node 4 (only) an exponentially distributed inter-arrival time with mean 5000.

AT -- absorption time, (in microseconds). This number must be followed by node range limits and distribution type, just as with parameter IT.

TT -- transmit-again time, (in microseconds).

QD -- queue loading delay, (in microseconds).

## 2.2 Link layer

The FODS access protocol, as executed at any individual node, involves two modes of operation: random-access and controlled-access. A node enters controlled-access mode after any collision occurs; it remains there until every node has had a chance to transmit without contention, and then switches back to random-access mode.

In random-access mode, a node with data ready to send may transmit anytime the trunk is "available" to it, meaning that the trunk has been locally "idle" (free of signal) for an immediately preceding continuous interval of at least the "gap time" (GT). When two or more nodes try to send almost simultaneously, their messages collide; the resulting noise burst propagates to every node in the network, causing each to

switch to controlled-access mode at the moment the collision is locally "resolved". (See below.)

Each contending sender reacts to collision detection by immediately broadcasting a jamming pulse, halting its current message transmission. At any node in the network, the collision is not "resolved" until the trunk has been idle there for a gap time following the end of the last jamming pulse, (so the trunk is available again). At this point the controlled-access mode begins, with its timeslot sequence.

In this sequence, each node starts an internal counter incrementing as soon as the collision is resolved there. The node reaches its unique instant of opportunity to initiate uncontested transmission, at the exact moment when its count reaches its own reserved timeslot index. There is a constant interval (the "slot width" SW, common to all nodes) between a node's counter increments, except when transmission by any node occurs. In that event, the counter is suspended at the current count when the channel traffic is sensed, and will resume the count (starting with another increment) as soon as the trunk becomes available again.

When the counter marks the end of the last timeslot, (its count having just exceeded 32, the maximum allowable number of nodes in the network), a random delay begins, (calculated independently for each node, every time it goes through controlled-access mode, as a product  $RS \times RN$ ). When this interval expires, or is interrupted by transmission by some other node that had a shorter random delay, the controlled-access mode is over; the node switches back to random-access mode.

The model parameters needed to characterize this layer are as follows:

GT -- gap time, (in microseconds).

SW -- slot width, (in microseconds).

RS -- random delay stepsize, (in microseconds). Each random delay consists of a random number of these time steps.

RN -- random delay maximum number of steps. This is the upper limit on uniformly distributed non-negative random integers which are multiplied by the fixed timestep RS to determine random delays.

### 2.3 Physical layer

Here are the model parameters needed to characterize this layer:

- NN -- number of nodes. At present, LANES I cannot model networks with more than 32 nodes. (However, this can easily be changed upon request.)
- SP -- speed of propagation, (in meters per second). This tells how fast signals travel in the medium to be modelled.
- TR -- transmission rate, (in megabits per second). This gives the bit rate of the information sent along the medium.
- AL -- arm length, (in meters). This is the distance from the central star coupler of the network out to a particular node (or to each of a subgroup of nodes). This number must be followed by the lower and upper node range limits, (as with parameter MS of the load layer, described above).

### Section 3. Setting Up LANES

LANES runs on a VAX 11/780 under the VMS operating system, and requires the INGRES database management system (from Relational Technology, Inc., in Berkeley, CA.). You must be a valid INGRES user, and there is a particular set of tables that must be present in any database you plan to use. Certain VMS text files must also be prepared.

Suppose you want to have a database named WHATEVER to use with LANES. You must first create it by typing "CREATEDB WHATEVER" to the VMS operating system \$ prompt. Then you need to open that database and create in it the tables required by LANES. Type "INGRES WHATEVER" to VMS, and you will get the INGRES \* prompt. To this, type "\I [LANES]LANES.DB". This creates the tables and prints a list of them for you. (The list should include tables ETEMP, MTEMP, QTEMP, DTEMP, STEMP, and ARCHVZZZZ.) Then type "\Q" to exit INGRES and return to the operating system.

To get the VMS text files that LANES will expect to find in your directory:

```
$ COPY [LANES]FOR008.DAT FOR008.DAT
$ COPY [LANES]LANES.DAT LANES.DAT
```

The file FOR008.DAT should be left as it stands; it is used by the special simulation software in LANES. The file LANES.DAT is a working example of the input file of parameter values, mentioned in Section 1. You can make others for your directory, but their names must all have the extension ".DAT". The recommended way to construct them is to start with LANES.DAT and use the LANES editing capabilities, mentioned in Section 1. The details of how to do this are discussed in Section 4.

The meanings of the model parameters are to be understood in the context of the discussion of FODS in Section 2. The control parameters are explained in Section 4.

## Section 4. Running LANES

When you have made the preparations described in Section 3, you can then type "RUN [LANES]LANES" to the VMS operating system prompt, to start the program. You will immediately be asked to enter the name of a file from which the input parameters can be read, or a carriage return to denote file LANES.DAT (which is what you will have to use when first running LANES, until you make alternate input files by using LANES). Since all input file names must have the extension ".DAT", any name you enter will automatically be converted to that form; any problem in opening or reading the file thus specified will result in a prompt for retry with some other filename. (At this point the only way to get out is to hit CTRL-Y, aborting the program.)

After successful reading of the input parameters, the program asks you to enter a database name (or carriage return if using FCDSIM). Any problem in opening the database causes the program to automatically abort. (However, even if the database name is valid, error conditions will still result later if that database does not have the right tables, as described in Section 3. You must check this yourself.)

Next, LANES prompts you for one of the main commands: Edit (or E), Simulate (S), Analyze (A), or Bye (B). The Bye command is used to terminate the program and return to the operating system. Each of the other three commands involves a choice of further options, for which you will be prompted upon entering the command. The table below briefly describes this structure.

Commands:	Options:	Functions:
-----		
Edit		Prepare input parameters for simulation.
	--	Change value(s) of any parameter specified by code.
	LM	List all model parameters with their current values.
	LC	List all control parameters with their current values.
	Read	Read in new parameter values from named input file.
	Write	Save all current parameter values to named input file.
	Exit	Return to main command level.
-----		

<b>Simulate</b>	<b>Execute simulation run(s).</b>
Read	Read in new parameter values from named input file.
Write	Specify ID for storing simulation results in database.
Go	Do the simulation.
Exit	Return to main command level.
-----	
<b>Analyze</b>	<b>Display analysis of simulation results.</b>
Read	Specify ID of stored simulation results to analyze.
Queues	Present queue statistics from specified simulation.
Delays	Present delay statistics from specified simulation.
Summary	Present summary statistics from specified simulation.
NR	Specify Node Range for the Queues and Delays options.
Exit	Return to main command level.
-----	
<b>By'</b>	<b>Terminate the program.</b>
-----	

The main commands, or the options within a chosen command, may be executed in any order, but you must Exit out of one main command to get to another. Results will depend on the information you interactively supply to some options, as well as the order of execution. Except for LM, LC, NR, and the codes of the input parameters, any command or option you select is sufficiently specified by its first letter alone. Entries may be in either upper or lowercase.

#### 4.1 Edit

Suppose you want to construct a new input file to be called NEW.DAT, starting with the parameter values found in LANES.DAT and changing some of them. Entering the Edit command enables you to perform the necessary operations. First you can use the Read option to get all the input parameter values from LANES.DAT, (but this is really only necessary if the input file read in at the beginning of the session was not LANES.DAT). You can look at the names, codes, and current values of all the model parameters at once with the LM option, and all the control parameters with LC. Then you can specify any model or control parameter whose value you want to change, by entering the two-letter code for that parameter, (as just another option). The

program will prompt you for the change, and acknowledge your response.

When you have made all of your changes to parameter values in this manner, you can use the Write option to copy the entire set of parameters, as updated, to the name NEW.DAT, thus creating a new input file.

The following example demonstrates this process. User responses are indicated by underlining.

```
Enter main command: (Edit, Simulate, Analyze, Bye) E
-----
List Model parameters      LM
List Control parameters   LC
Read new input parameters  R
Write current inputs       W
Exit the function          E
```

Enter code for selected option or parameter: R

Enter name of input file to be read (or @ to quit this option): LANES

... Now reading file LANES.DAT ....

```
-----
List Model parameters      LM
List Control parameters   LC
Read new input parameters  R
Write current inputs       W
Exit the function          E
```

Enter code for selected option or parameter: LM

```
number of nodes      NN      4.0000
speed of propagation SP    200000000.0000
transmission rate    TR      100.0000
header size          HS      112.0000
transmit-again time  TT      600.0000
queue loading delay  QD       5.0000
slot width           SW       1.7000
gap time             GT       1.7000
random delay time step RS      0.1000
random delay number of steps RN  16.0000
arm length           AL      25.0000    1.  4.
message size         MS     8000.0000    1.  4.
inter-arrival time   IT     2000.0000    1.  4.  1.
absorption time      AT      700.0000    1.  4.  2.
-----
```



List Model parameters	LM
List Control parameters	LC
Read new input parameters	R
Write current inputs	W
Exit the function	E

Enter code for selected option or parameter: LC

output volume	OV	4.0000
statistics collection	SC	1.0000
run-time	RT	12000.0000
number of iterations	NI	1.0000
iteration parameter	IP	IT
iteration step size	IS	1000.0000
maximum queue length	MQ	100.0000

-----	----
List Model parameters	LM
List Control parameters	LC
Read new input parameters	R
Write current inputs	W
Exit the function	E

Enter code for selected option or parameter: NN

number of nodes	NN	4.0000
-----------------	----	--------

Enter NUMERICAL value: 6

number of nodes	NN	6.0000
-----------------	----	--------

-----	----
List Model parameters	LM
List Control parameters	LC
Read new input parameters	R
Write current inputs	W
Exit the function	E

Enter code for selected option or parameter: IT

inter-arrival time	IT	2000.	1.	4	1.
inter-arrival time	IT	0.	5.	6.	0.

Enter 4 NUMERICAL values: 3500.3. 99 1

inter-arrival time	IT	2000.	1.	2.	1.
inter-arrival time	IT	3500.	3.	6.	1.

List Model parameters	LM
List Control parameters	LC
Read new input parameters	R
Write current inputs	W
Exit the function	E

Enter code for selected option or parameter: W

Enter filename to save current inputs (or @ to quit this option): LANES

File LANES.DAT already exists. Want new version? (Y/N) N

Enter filename to save current inputs (or @ to quit this option): NEW

.. Now writing to input file NEW.DAT ....

-----	----
List Model parameters	LM
List Control parameters	LC
Read new input parameters	R
Write current inputs	W
Exit the function	E

Enter code for selected option or parameter: E

Enter main command: (Edit, Simulate, Analyze, Bye) ....  
.....

Among the points illustrated in the above scenario, note especially the following:

- Remember that any input file name is forced to have the extension ".DAT". (The highest version number for that file is always used.)
- Numbers can be entered with or without decimal points, and if it is necessary to enter more than one, they can be separated by spaces, commas, and/or carriage returns. (Numbers should not be entered in exponential notation.)
- When you increase the number of nodes (NN), be sure you also update the sets of values for all of the "node-specific" parameters (AL, MS, IT, and AT), so as to include the added nodes.

## 4.2 Simulate

The control parameters determine the following aspects of a simulation:

- NI -- number of iterations. You can do a single run, or a series featuring systematic variation of the value of a selected model parameter.
- IP -- iteration parameter. This is the code specifying the model parameter whose value is to be varied, in a simulation series. (It has no meaning when NI = 1.) The only IPs presently supported are NN, AL, MS, IT, and AT. If NN is selected, then at each successive iteration the last subgroup of nodes for each node-specific parameter will automatically be extended to include the new node(s) added. For example, if NN = 4, and nodes 3 through 4 have the value 50.0 for AL, this same value will be assigned to nodes 5 on up, as the modelled network expands.
- IS -- iteration stepsize, (in the units of the IP). This is the increment in value applied to the IP at each successive iteration in a series. (This, too, is meaningless when NI = 1.) For instance, in the case where NI is 3, the IP is NN, and the current value of NN is 4, if you set IS = 2, then the values of NN for the three iterations in the simulation series will be 4, 6, and 8.
- Be aware that after such a simulation series is executed, the current value of NN will have changed to 8, which will be used (unless you change it back) in any further simulations! If the chosen IP is one of the node-specific parameters, then the stepsize increment is applied equally to all nodes at each successive iteration in a series.
- RT -- run-time, (in microseconds). In a series, this applies to every iteration.
- SC -- statistics collection, (in microseconds). This is the time at which to start collection of run statistics (on queues, delays, collisions, etc.). The lowest allowable value is 0.0, corresponding to the very beginning of the run. In a series, this applies to all iterations.
- OV -- output volume. This controls the automatic display of simulation results from a single run (NI = 1). The type of simulation output depends as follows on the value of OV:

- < = 0: None
- = 1: Event time trace
- = 2: Message history
- > = 3: Both 1 and 2

MQ -- maximum queue length. (This is not implemented at present.)

The Read option under Simulate allows input file selection in the same manner as Read under the Edit command.

When you execute a simulation (using the G option), there is an identifying label applied to the set of input parameters and to the names of the database tables that store the results. You determine this label in advance, by either accepting the default label read in with the input file (which is "TEMP" in your initial version of LANES.DAT) or changing it with the W option under Simulate. This W option asks you for a string of no more than 11 alphanumeric characters, to label the simulation. (If more than 11 characters are entered, the label is truncated to the first 11 of them.) This same label will now also apply in subsequent use of the Analyze command, unless changed with the R option there.

The G option starts execution of a simulation, using the current values of all input parameters, and writing results to the database using the label currently in effect (as read in from an input file or changed with the W option). If you already have simulation results archived under this label, the program asks whether to overwrite them or to cancel this simulation, except when the label is "TEMP". Any stored simulation results with the label "TEMP" are always overwritten!

### 4.3 Analyze

If you want to look at results from some simulation identified with a label different from the one currently in effect, you can reset the label by using the R option under Analyze. This R option asks for a string of no more than 11 alphanumeric characters (or truncates a longer entry to the first 11), to identify archived simulation results for display and analysis.

Options Q, D, and S display analysis of simulation results stored under the label currently in effect, (which was read in from an input file, or reset more recently with either the Simulate W option or the Analyze R option). If there are no tables in the database with names keyed by that label, you will

be notified and returned to the option list. Output provided with these options is as specified in the REQ.DA document.

The NR option asks for lower and upper limits (in that order) on the range of nodes for which the Q and D output is to be displayed.

## Section 5.0 Further Resources

It is also possible to examine and analyze simulation results, with greater power and flexibility, by directly using INGRES. For more information on this or any other matter related to the use of LANES I, contact Joe Jordan of Informatics General Corporation, or Terry Grant, NASA Ames Research Center, at 415/694-6526 or -6533.

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16. Abstract  This document is intended for users of the Local Area Network Extensible Simulator, version I. This simulator models the performance of a Fiber Optic network under a variety of loading conditions and network characteristics. The options available to the user for defining the network conditions are described in this document. Computer hardware and software requirements are also defined.					
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